Energy and Emergy in Agroecosystems

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Energy in Agroecosystems

- Energy is what the ecosystems capture and transform
- Much of the energy is transformed into heat energy and it is lost from the ecosystem.
- Agroecosystems are used to harvest solar energy and to transfer it to biomass.

Energy in Agroecosystems

- **Energy inputs are required by agroecosystems because of:**
  - **The deviation from the natural processes**
  - **Heavy removal of energy by the harvested crops**
- **Conventional agriculture uses great amounts of energy that come from non-renewable fossil fuels.**
- **In many crops more energy is put than harvested back.**

Energy in Agroecosystems

- Crop plants are among the most efficient plants in capturing and transforming solar energy.
- Crop plants efficiency in capturing and converting energy to biomass varies due to their differences in:
  - Photosynthetic efficiency
  - Physiology
  - Plant morphology

Energy inputs in agroecosystems

- **Energy is required for:**
  - **Maintaining the agroecosystem low diversity**
  - **Limiting interference**
  - **Modifying the physical and chemical conditions**
- **Larger inputs enable higher yields**

Energy inputs in agroecosystems

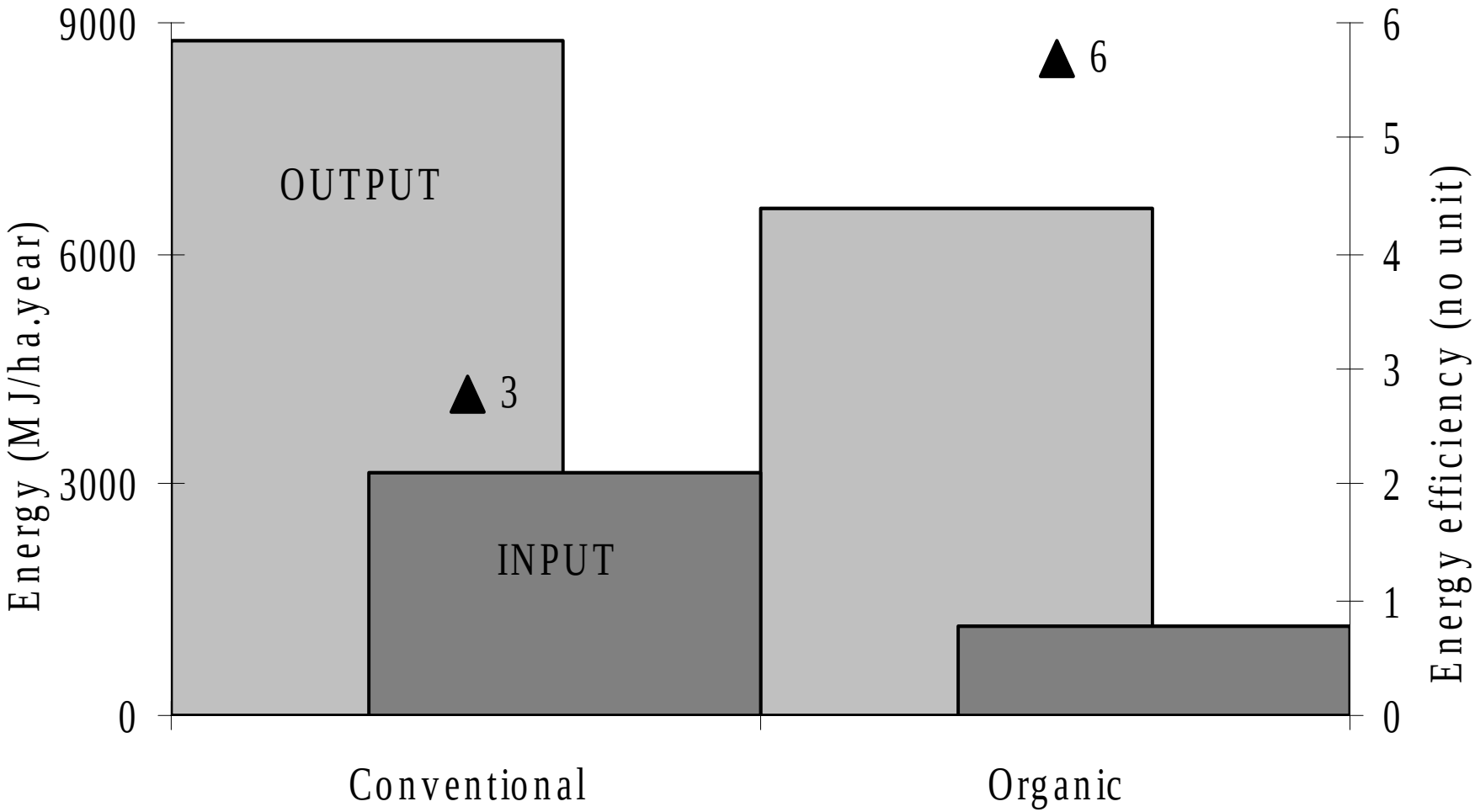
- Solar energy (ecological)
- Additional (cultural) inputs :
  - Industrial in the form of energy for :
    - machinery and fuels
    - tools
    - seed
    - fertiliser
    - pesticides
    - and distribution of irrigation water
    - food processing and transportation
  - biological
    - Human labour
    - Animal labour
    - Compost
    - Animal manures
    - Biogass

Cumulative energy assessment of three apple production systems

(Reganold, et. al. 2001)

	Organic	Conventional	Integrated
Energy in (MJ ha^{-1})			
Labour (h ha^{-1})	2,921	2,008	2,147
Labour	2,337	1,607	1,718
Machinery	73,974	73,560	73,560
Fuel	173,400	182,919	182.919
Electricity	10,794	10,794	10,794
Fertiliser	311	16,255	8,901
Inscecticide	22,159	42,313	40,375
Fungicide	18,023	12,922	12,855
Weed control	141	31,931	13,350
Infrastructure	144,188	144,188	144,188
Total input	445,328	516,489	488,661
Total output	526,544	570,745	550,076
Output/Input	1,18	1,11	1,13

Energy efficiencies of organic and conventional olive groves



Energy inputs in agroecosystems

- Cultural energy requirements in agroecosystems are closely related to the level of modification of natural ecosystem processes.
- Energy efficient food production is possible by
  - Changing the way industrial cultural energy is used
  - Decreasing inputs of industrial cultural energy
  - Increasing biological cultural energy

Energy inputs in agroecosystems

- **Fossil fuel consumption in agriculture is extensively used since its mechanisation.**
- **Conventional agroecosystems rely heavily on industrial cultural energy inputs.**
- **Industrial cultural inputs are used:**
  - **Directly**
    - **Through the inputs**
  - **Indirectly**
    - **Off the farm to produce the machinery, chemical inputs etc.**

Energy inputs in agroecosystems

- **Most of the industrial cultural energy inputs in agriculture come from fossil fuels or are dependent on fossil fuels for their manufacturing**
  - **Anything that effects the cost or the availability of fossil fuels have dramatic impacts on agriculture.**
- **Conventional agriculture is using more energy to produce food than that the food contains.**
  - **Most of this energy comes from sources of finite supply.**

Energy inputs in agroecosystems

- The extensive use of cultural energy inputs permits the ignorance of ecological processes and simplification of cropping systems.
- Ignoring ecological processes leads to environmental degradation in agroecosystems.
- Fossil fuel based agriculture enables large scale mechanised agriculture
  - Social problems are created.

Energy inputs in agroecosystems

- **Sustainable food production depends on:**
  - **Efficient use of energy**
  - **Reliance on industrial cultural energy inputs**

Energy inputs in agroecosystems

- **Sustainable agriculture from an energy point of view:**
  - **Reduction of industrial cultural energy**
  - **Increased use of biological cultural energy**
  - **Design of agroecosystems that require lower levels of cultural energy inputs**

Reduction of industrial cultural energy

- Use of minimum tillage
- Water saving practices
- Rational crop rotations
- Replacing fossil fuels with renewable energy
- Developing and application of on farm sources of renewable energy
- Efficient use of industrial cultural energy
- Reduce overconsuption of animals raised in factory farms
- Rationalise transportation and regionalise production

Increased use of biological cultural energy

- **Increased use of biological cultural energy**
  - **Use of organic fertilisers for maintaining soil fertility and quality**
  - **Recycle nutrients locally and on farm**
  - **Extensive use of biological control and integrated pest management**
  - **Increase local use of agricultural products**

Agroecosystem design for lower levels of energy inputs

- **Design of agroecosystems that require lower levels of cultural energy inputs**
  - **Increased use of denitrogen fixation and green manures**
  - **Pest management through:**
    - **Cover cropping**
    - **Intercropping**
    - **Promotion of beneficials**
  - **Use of crops adapted to the local agroclimatic condition**

Emergy

- **Emergy is a technique which can determine and measures the values of resources, services and commodities on a common counting base – the solar energy it took to make them.**

- **Emergy theory developed the last three decades as tool for environmental policy and for evaluating quality of resources in the dynamics of complex systems (Brown and Ulgiati, 1997)**

Emergy

- Emergy is often referred to as energy memory (Odum, 1998).
- Emergy evaluation is based on the principles of energetics, system theory and system ecology.
- The units are (Odum, 1996):
  - sej – solar energy joules
  - emdolars – equivalent when compare with evaluation with monetary terms

Emergy

- Emergy can not be measured directly.
- The emergy value of a product or service is calculated with the use of a multiplication factor.
- The multification factor is called transformity value and gives a measure of the concentration of solar energy through a hierarchy of process or levels.
- Transformities
  - makes the emergy evaluation method relatively fast to calculate.
  - are difficult to be assessed.

Emergy

- **Emergy indices are used to evaluate areas like**
  - **primary energy sources of economies,**
  - **environmental impacts,**
  - **economic production sectors**
  - **restoration and sustainable use of agroecosystems**
  - **international trade**